

Global evidence linking local development-driven urban actions with climate change mitigation and adaptation outcomes

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1. Search strategy.

In our study, following the PRISMA guidelines for the systematic review procedure, we developed an artificial intelligence (AI)-assisted and human-in-the-loop information extraction pipeline to ensure both efficiency and reliability.

First, we created a series of search strings to capture important dimensions to find literature pertinent to the research topic. These dimensions included study objects (urban actions and underlying local urban development topics), climate outcomes (synergy or trade-off), and outcomes (socio-economic performance and cost-benefits). We identify studies that frame urban development within the context of interactions (e.g., synergies and trade-offs) and those that state costs or benefits, thereby excluding literature limited to singular descriptions of urban actions, also facilitating subsequent identification of the impact of urban actions (characterization of impact direction). We created the search strings iteratively to guarantee sufficient coverage across development topics. The initial search was conducted by human reviewer (ZH & SJJ) in September 2025 using title and abstract fields in Scopus and web of science databases. The final search covered 18 development related topics. Table S 1 presents the search strategy.

Table S 1 Search strings.

Number	Topic	Keywords
1	Health	<i>'health', 'healthy', 'wellbeing', 'well-being', 'pandemic', 'mortality', 'morbidity' OR 'disease', 'infection', 'pandemic', 'epidemic'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>
2	Equity & Inclusion	<i>('equity', 'social justice', 'justice', 'vulnerability', 'vulnerable', 'inclusive', 'gender', 'rights', 'poverty', 'livelihood', 'household', 'communities', 'community-based', 'indigenous knowledge', 'participation', 'participatory', 'population growth', 'demographics') ,</i>

		<p>(<i>'city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'</i>), (<i>'trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'</i>), (<i>'cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits'</i>)</p>
3	Education & Skills	<p>(<i>'education', 'labor force', 'skills development', 'employment', 'digital literacy', 'human capital', 'job', 'skills training', 'educational facilities', 'labor force', 'workforce'</i>),</p> <p>(<i>'city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'</i>), (<i>'trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'</i>), (<i>'cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits'</i>)</p>
4	Air & Pollution	<p>(<i>'air quality', 'air pollution', 'particulate matter', 'PM2.5', 'ozone control', 'ozone pollution', 'industrial emissions', 'marine pollution', 'plastic pollution', 'microplastics', 'toxic exposure', 'chemical safety', 'environmental health', 'environmental degradation', 'sanitation', 'waste', 'chemical exposure'</i>),</p> <p>(<i>'city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'</i>), (<i>'trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover</i></p>

		<i>impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>
5	Water & Soil	<i>('water quality', 'wastewater', 'stormwater', 'runoff', 'pesticides', 'agricultural pollution', 'eutrophication', 'land degradation', 'land restoration', 'land management', 'water scarcity', 'water pollution', 'water contamination', 'soil contamination', 'heavy metals'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>
6	Food & Nutrition	<i>('agriculture', 'food systems', 'agroecology', 'diets', 'food loss', 'food waste', 'nutrient', 'hunger', 'hungry', 'food security', 'food nutrition', 'food supply', 'malnutrition'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>
7	Biodiversity & Ecosystems	<i>('biodiversity', 'species loss', 'conservation', 'ecosystem', 'habitat', 'protected areas', 'deforestation', 'reforestation', 'afforestation', 'wetland', 'marine', 'fisheries', 'aquaculture', 'forest'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-</i>

		<p><i>level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i></p>
8	Industrial & Economic	<p><i>('industrial policy', 'industrial transition', 'overcapacity', 'capacity reduction', 'phase-out', 'coal exit', 'just transition', 'lock-in', 'subsidy reform', 'retrofitting', 'green finance', 'economic transition', 'financial policy', 'budget', 'investments', 'carbon pricing', 'stranded assets', 'debt', 'market', 'business', 'carbon trading', 'real estate'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i></p>
9	Circular Economy	<p><i>('green product', 'green production', 'sustainable production', 'sustainable product', 'sustainable products', 'circular economy', 'resource efficiency', 'material flow', 'reuse', 'recycling', 'sustainable consumption', 'supply chain', 'certification', 'carbon labeling', 'energy labeling', 'eco-design', 'eco-friendly', 'loop closing', 'loop-closing'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended</i></p>

		<i>consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>
10	Governance & Policy	<i>('regulation', 'regulatory', 'license', 'licence', 'policy implementation', 'development priority', 'spatial planning', 'stakeholder', 'institutional capacity', 'initiatives', 'intervention', 'interventions', 'service delivery', 'planning', 'administrative', 'administration', 'policy instruments'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>
11	Natural Resource Governance	<i>('land tenure', 'natural resource', 'fisheries', 'multi-level governance', 'policy coherence', 'transparency', 'accountability', 'enforcement capacity', 'energy transition', 'land use', 'land management'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>
12	Energy & Low-Carbon Tech	<i>('renewable', 'energy efficiency', 'solar energy', 'heating', 'cooling', 'cooling-roof', 'electrification', 'grid', 'energy poverty', 'hydrogen', 'CCUS', 'carbon capture', 'waste valorization', 'distributed energy', 'photovoltaics'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'm</i>

		<p><i>unicipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban') , ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i></p>
13	Urban Housing & Livability	<p><i>('informal', 'settlements', 'slum', 'renewal', 'housing', 'liveability', 'walkability', 'aesthetics', 'public space', 'overcrowding', 'homelessness', 'amenities'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban') , ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i></p>
14	Transport & Mobility	<p><i>('transport', 'mobility', 'EV', 'electric vehicle', 'last mile', 'modal shift', 'accessibility', 'traffic', 'bike share', 'commute', 'commuting', 'metro', 'subway', 'underground') , ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban'), ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i></p>

15	Digital & Smart City	<p><i>(‘IoT’, ‘digital’, ‘big data’, ‘sensors’, ‘AI’, ‘smart’, ‘platform’, ‘technology’, ‘technologies’, ‘innovation’, ‘innovative’, ‘digitalization’, ‘infrastructure’, ‘intelligent’),</i></p> <p><i>(‘city’, ‘cities’, ‘urban’, ‘urbanization’, ‘urbanisation’, ‘metropolitan’, ‘metropolis’, ‘municipal’, ‘municipality’, ‘municipalities’, ‘town’, ‘towns’, ‘township’, ‘master plan’, ‘zoning plan’, ‘local’, ‘civic’, ‘city-level’, ‘urban-level’, ‘suburb’, ‘suburbs’, ‘suburban’), (‘trade-off’, ‘trade-offs’, ‘conflicting’, ‘conflict’, ‘competing’, ‘competition’, ‘coherence’, ‘priority alignment’, ‘win-win’, ‘zero-sum’, ‘mutual exclusion’, ‘co-benefits’, ‘co-benefit’, ‘synergies’, ‘synergy’, ‘negative externalities’, ‘compromise’, ‘unintended consequences’, ‘unintended consequence’, ‘spillover effects’, ‘spillover impacts’, ‘spillover effect’, ‘spillover impact’, ‘priorities’), (‘cost’, ‘benefit’, ‘costs’, ‘benefits’, ‘cost-benefit’, ‘cost-benefits’)</i></p>
16	Culture & Heritage	<p><i>(‘cultural heritage’, ‘historic preservation’, ‘culture’, ‘social cohesion’, ‘placemaking’, ‘community identity’, ‘heritage conservation’, ‘neighborhood’, ‘cultural landscape’),</i></p> <p><i>(‘city’, ‘cities’, ‘urban’, ‘urbanization’, ‘urbanisation’, ‘metropolitan’, ‘metropolis’, ‘municipal’, ‘municipality’, ‘municipalities’, ‘town’, ‘towns’, ‘township’, ‘master plan’, ‘zoning plan’, ‘local’, ‘civic’, ‘city-level’, ‘urban-level’, ‘suburb’, ‘suburbs’, ‘suburban’), (‘trade-off’, ‘trade-offs’, ‘conflicting’, ‘conflict’, ‘competing’, ‘competition’, ‘coherence’, ‘priority alignment’, ‘win-win’, ‘zero-sum’, ‘mutual exclusion’, ‘co-benefits’, ‘co-benefit’, ‘synergies’, ‘synergy’, ‘negative externalities’, ‘compromise’, ‘unintended consequences’, ‘unintended consequence’, ‘spillover effects’, ‘spillover impacts’, ‘spillover effect’, ‘spillover impact’, ‘priorities’), (‘cost’, ‘benefit’, ‘costs’, ‘benefits’, ‘cost-benefit’, ‘cost-benefits’)</i></p>
17	Resilience	<p><i>(‘earthquake’, ‘heat wave’, ‘typhoon’, ‘flood’, ‘drought’, ‘heat stress’, ‘heat wave’, ‘heatwave’, ‘resilience’, ‘resilient’, ‘nature-based’, ‘vegetation’, ‘restoration’, ‘trees’, ‘greening’, ‘green space’, ‘sea-level’, ‘drought’, ‘natural hazard’, ‘extreme event’),</i></p> <p><i>(‘city’, ‘cities’, ‘urban’, ‘urbanization’, ‘urbanisation’, ‘metropolitan’, ‘metropolis’, ‘municipal’, ‘municipality’, ‘municipalities’, ‘town’, ‘towns’, ‘township’, ‘master plan’, ‘zoning plan’, ‘local’, ‘civic’, ‘city-level’, ‘urban-level’, ‘suburb’, ‘suburbs’, ‘suburban’), (‘trade-off’, ‘trade-offs’, ‘conflicting’, ‘conflict’, ‘competing’, ‘competition’, ‘coherence’, ‘priority</i></p>

		<i>alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>
18	Risk & Safety	<i>('risk management', 'early warning', 'disaster', 'risk reduction', 'preparedness', 'public safety', 'crime', 'emergency', 'epidemic response', 'security', 'conflict', 'hazard'), ('city', 'cities', 'urban', 'urbanization', 'urbanisation', 'metropolitan', 'metropolis', 'municipal', 'municipality', 'municipalities', 'town', 'towns', 'township', 'master plan', 'zoning plan', 'local', 'civic', 'city-level', 'urban-level', 'suburb', 'suburbs', 'suburban') , ('trade-off', 'trade-offs', 'conflicting', 'conflict', 'competing', 'competition', 'coherence', 'priority alignment', 'win-win', 'zero-sum', 'mutual exclusion', 'co-benefits', 'co-benefit', 'synergies', 'synergy', 'negative externalities', 'compromise', 'unintended consequences', 'unintended consequence', 'spillover effects', 'spillover impacts', 'spillover effect', 'spillover impact', 'priorities'), ('cost', 'benefit', 'costs', 'benefits', 'cost-benefit', 'cost-benefits')</i>

* For each search string, terms in parentheses use OR, and terms outside use AND.

2. Prompt design

Only journal publications, including research, conference, report, and review articles, were considered. To screen the 58,047 records, we used an LLM-assisted inclusion and exclusion procedure in which the model was prompted to perform three independent runs for each record, with the final decision (i.e., “include” or “exclude”) determined by majority voting. Prompts are detailed in Table S 2.

Table S 2 AI-assisted screening prompt

<p>Instruction:</p> <p><i>Please summarize the abstract of a full research article and determine whether to include, exclude, or mark as unclear based on the following criteria. Focus on studies that report actions or policies or solutions driven by cities' own needs and explore trade-offs and costs related to climate mitigation and adaptation, including real-world urban actions not primarily targeting climate goals.</i></p> <p>Inclusion Criteria:</p> <ul style="list-style-type: none"> - <i>The paper includes specific urban case studies and analyzes actions or policies or solutions or technologies driven by needs or priorities (e.g., economic growth, social equity, infrastructure, investment, social programs, health).</i> - <i>Papers that considers synergies, trade-offs, co-benefits, or conflicts between urban actions and climate mitigation and/or adaptation efforts should be included.</i> - <i>Papers that considers economic, social, or environmental costs related to these actions should be included.</i> - <i>or paper compares different urban types (e.g., developed/developing) or stages of development.</i> <p>Exclusion Criteria:</p> <ul style="list-style-type: none"> - <i>Studies that only discuss urban actions without linking them to specific urban development topics or climate outcomes.</i> - <i>Theoretical or modeling-only papers without empirical case studies.</i> - <i>Book chapters or conference proceedings collections (individual conference papers can be included).</i> - <i>Abstract/title insufficient to determine relevance.</i> - <i>National or global scale studies without city-level focus.</i> <p>Output format:</p> <p><i>answer=[included/excluded/unclear]</i></p> <p><i>\nreason=A brief explanation</i></p>

Knowledge extraction was performed using large language models (LLMs) accessed via API. For prompt development, we first tested the workflow on a subset of 50 titles and abstracts, and compared LLM outputs against human-reviewed consensus labels to assess extraction precision. Based on these evaluations, prompts were iteratively refined and incorporated into the final pipeline. The temperature parameter was fixed at 0.3 to ensure stable outputs, with a 30-second request timeout. Prompts are shown in Table S 3 and Table S 4.

Table S 3 Knowledge Extraction prompt for Round 1

<p>Instruction:</p> <p><i>1. Action motivation</i></p>

Definition: Action_motivation refers to the urban problem to be addressed or the development goal to be achieved, not the action or method used.

Instructions:

- Quote the original sentence or phrase from the original text that expresses the motivation or purpose, if available.*
- Provide a concise phrase (no more than 10 words) summarizing the purpose.*
- Focus on the actual intention of the city or implementing organization, not the research aim of the authors.*

2. Motivation_Source:

"Explicit" if the purpose is directly stated in the abstract.

"Inferred" if the purpose is derived from context.

3. Primary_action

Definition: Sub_action refers to the primary action, solution, intervention, or implementation pathway used to achieve the Action_motivation—that is, what the city, implementer, or people actually do / will do.

Policies, market mechanisms, or funding tools should be selected only when they constitute the primary intervention by the implementer.

Tools or models used solely to plan, assess, or support another action should be classified according to the action being implemented, not the tool itself, and are included only when they constitute the primary intervention by the implementer.

Key Rules

All classifications must be traceable to the compressed evidence text.

Purpose and Solution must be clearly distinguished.

Do not base judgments about urban actions or solutions on common sense, background knowledge, or speculation. Any field must be based entirely on descriptions that explicitly appear in the text or content that can be directly inferred. Output must be in strict JSON format:

```
{{  
  "Action_motivation": "",  
  "Motivation_Source": "Explicit/Inferred",  
  "Primary_action": ""  
}}
```

Table S 4 Knowledge Extraction prompt for Round2

Instruction:

Read the given title and abstract carefully, and extract structured information strictly based on the text.

Our task is to extract, compress, and classify the information strictly based on the original text. Do not introduce new information.

Follow the exact extraction rules below:

1. Motivation_category

Select exactly one category that best represents the main thematic area of the extracted Action_Motivation, not the action or co-benefits.

Options:

[Circular Economy, Coastal and Marine, Development & Infrastructure, Ecosystem & Biodiversity, Energy Transition & green economy, Food & Agriculture, Health &

Pollution, Poverty & Social Equity, Transport & Mobility, Urban Resilience, Water Security & Management]

This field must be completed, and the value must be selected from the list above.

2. Action_category

Classify the extracted Primary_action based on the following abstract text.

Options:

[Agriculture & Food Systems, Construction & Building, Energy Solutions, Land Use & Spatial Planning, Nature-based & Ecosystem, Resilience Enablers/Tools, Transition knowledge/Government, Transport & Mobility, Waste & Circular Economy, Water Management]

This field must be completed, using one option from the list.

3. Climate change outcome

Assess climate change outcome strictly based on explicit evidence in the text.

"Climate_Mitigation": "positive" if the measure reduces emissions, "negative" if it increases emissions, "" if no evidence.

"Climate_Adaptation": "positive" if the measure enhances resilience or reduces climate risks, "negative" if it increases vulnerability, "" if no evidence.

Key Rules

All classifications must be traceable to the compressed evidence text.

Purpose and Solution must be clearly distinguished.

Do not base judgments about urban actions or solutions on common sense, background knowledge, or speculation. Any field must be based entirely on descriptions that explicitly appear in the text or content that can be directly inferred. Output must be in strict JSON format:

format:

```
{{  
  "Action_motivation": "",  
  "Motivation_category": "",  
  "Primary_action": "",  
  "Action_category": "",  
  "Climate_Mitigation": "",  
  "Climate_Adaptation": ""  
}}
```

3. Supplementary table and figures

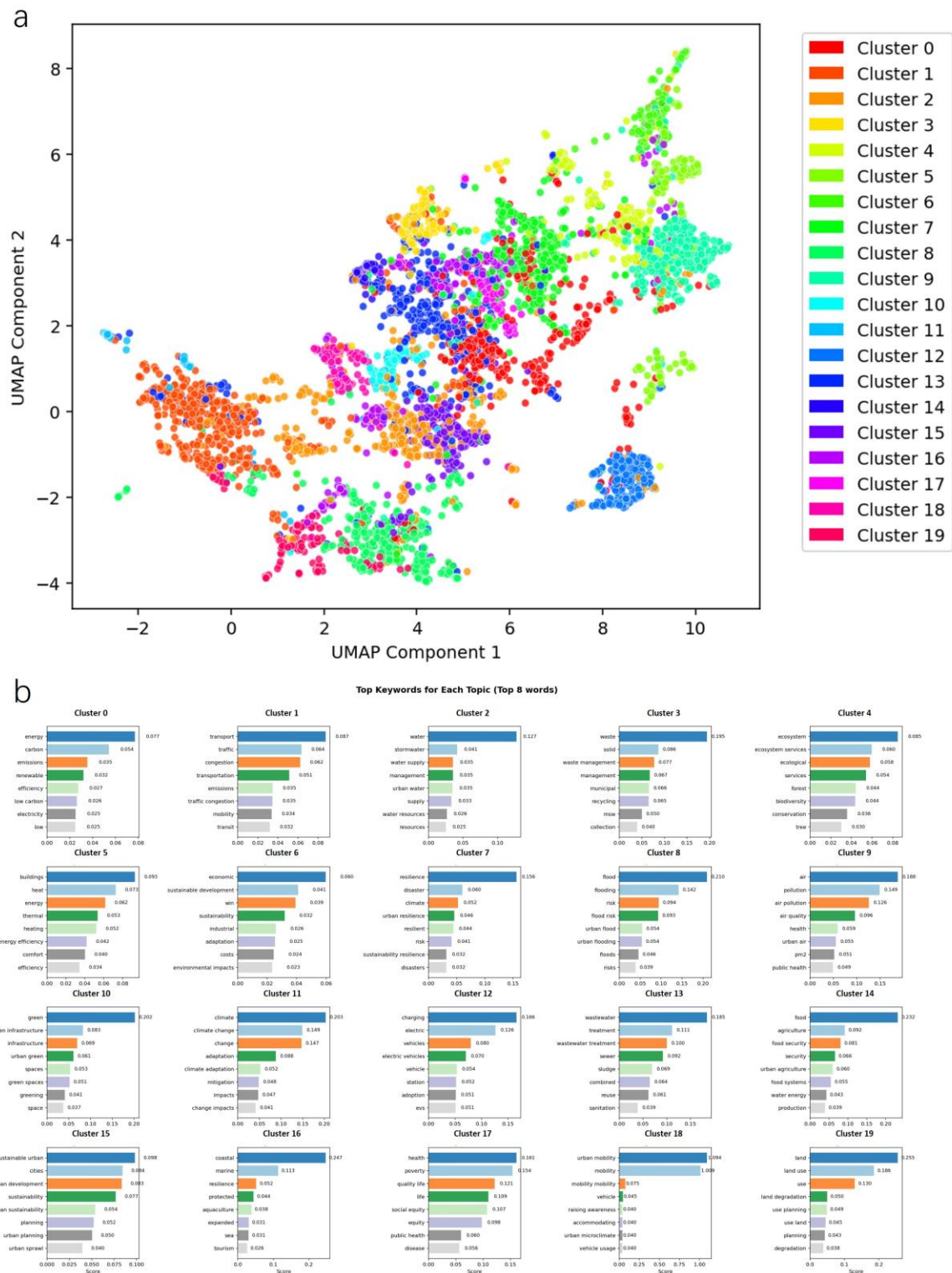


Figure S 1 Clustering of local development topics.

(a) Distribution of the initial local development topic topics identified by the BERTopic model. The axes represent the first two dimensions derived from UMAP

dimensionality reduction. Data points are color-coded using a rainbow gradient according to their topic index. (b) Keywords associated with each topic.

Table S 5 Mapping of clusters to local development topics

Local Development topics	BERTopic clusters
Transport Accessibility and Efficiency	1,12,18
Coastal and marine development	16
Biodiversity and Ecosystem Health	4
Green Energy and Economy Transition	0,11
Social Equity and Inclusive Services	17
Sustainable Infrastructure and Urbanization	6,10,15,19
Pollution Control and Public Health	9
Urban Resilience and Risk Reduction	5,7,8,11
Resource Efficiency and Circularity	3
Food Security and Sustainable Agriculture	14
Water Safety and Reliability	2,13

Table S 6 Hierarchy of major action categories and sub-categories action

Major-categories action	Sub-categories action
Agriculture & Food Systems	Agroforestry
	Dietary shifts
	Improved cropland management
	Reduce food loss and food waste
	Soil health management
Construction & Building	Change in construction materials
	Efficient buildings
	Energy-demand avoidance
	High-performance new building
	Improvement building stock
Energy Solutions	Bioenergy
	District heating & cooling networks

	Energy efficiency
	Energy supply / Renewables
	Fuel switching
	Geothermal energy
	Hydropower
	Resilient power systems
	Solar energy
	Wind energy
Integrated Knowledge or Governance	Integrated Knowledge or Governance
Land Use & Spatial Planning	Coastal zone management
	Land use and spatial planning
Nature-based & Ecosystem	Coastal defense and hardening
	Ecological connectivity
	Ecosystem restoration
	Forest-based adaptation
	Green and blue infrastructure
	Green infrastructure
	Ocean ecosystem services
	Urban afforestation
Resilience Enablers/Tools	Climate services
	Coastal defense and hardening
	Disaster risk management
	Social safety nets
Transport & Mobility	Electric light-duty vehicle tech
	Fuel-efficient light-duty vehicle tech
	Integrated modal-demand shift
	Shared automated electric mobility systems
	Non-motorized transport
	Public transport
	Transport fuel switching
Waste & Circular Economy	Circular material flows

	Enhanced recycling
	Solid waste management
	Waste prevention, minimization and management
Water Management	Integrated Water Management
	Stormwater Management
	Water use efficiency



Figure S 2 The (a) local development topics and (b) urban action categories by within-region share, bubble size and percentages indicate the share.

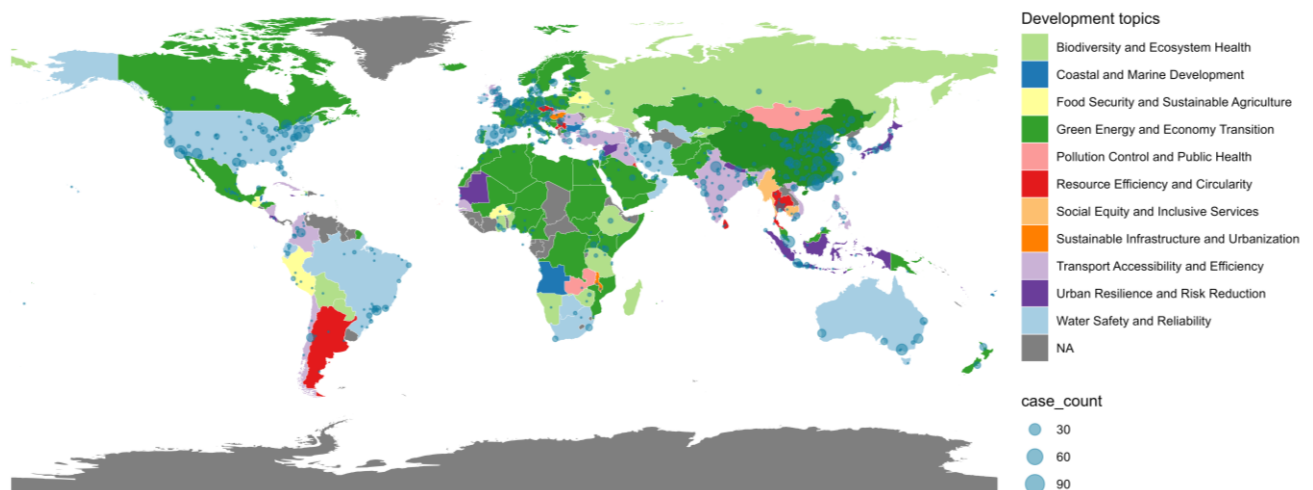


Figure S 3 Geographic distribution of studies and their underlying development topics across countries.

Countries are colored by the development topic with the highest number of studies. Specific city cases are overlaid as point symbols, with size indicating the number of cases in each urban area.

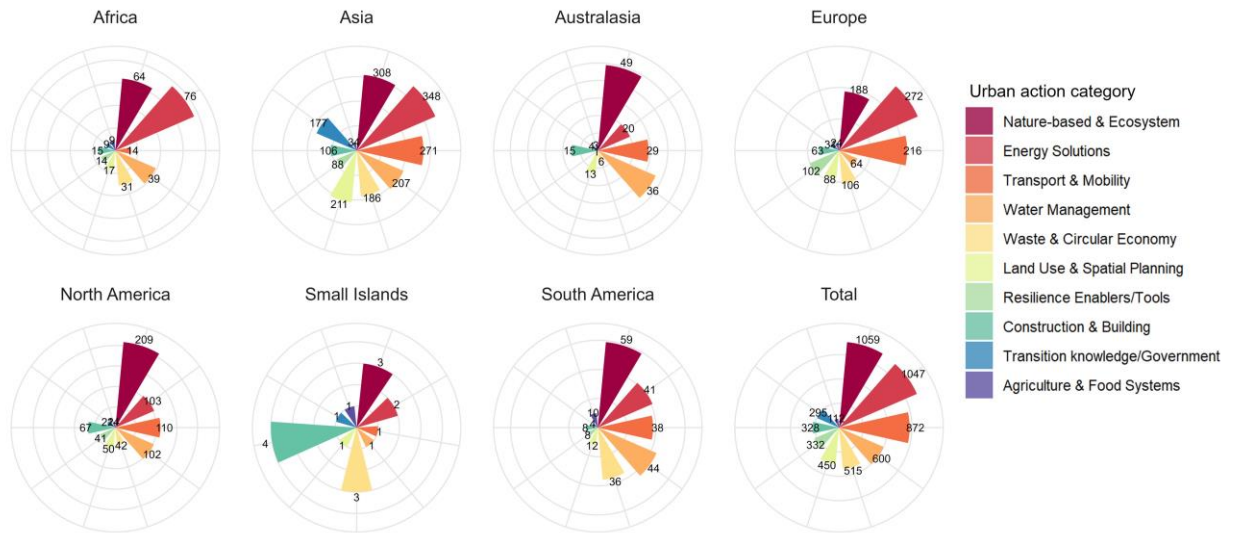


Figure S 4 Distribution of evidence across urban action categories by eight regions.

For each region, the number of cases within each major action category is aggregated and displayed. Bar height represents the number of documented cases in each category.

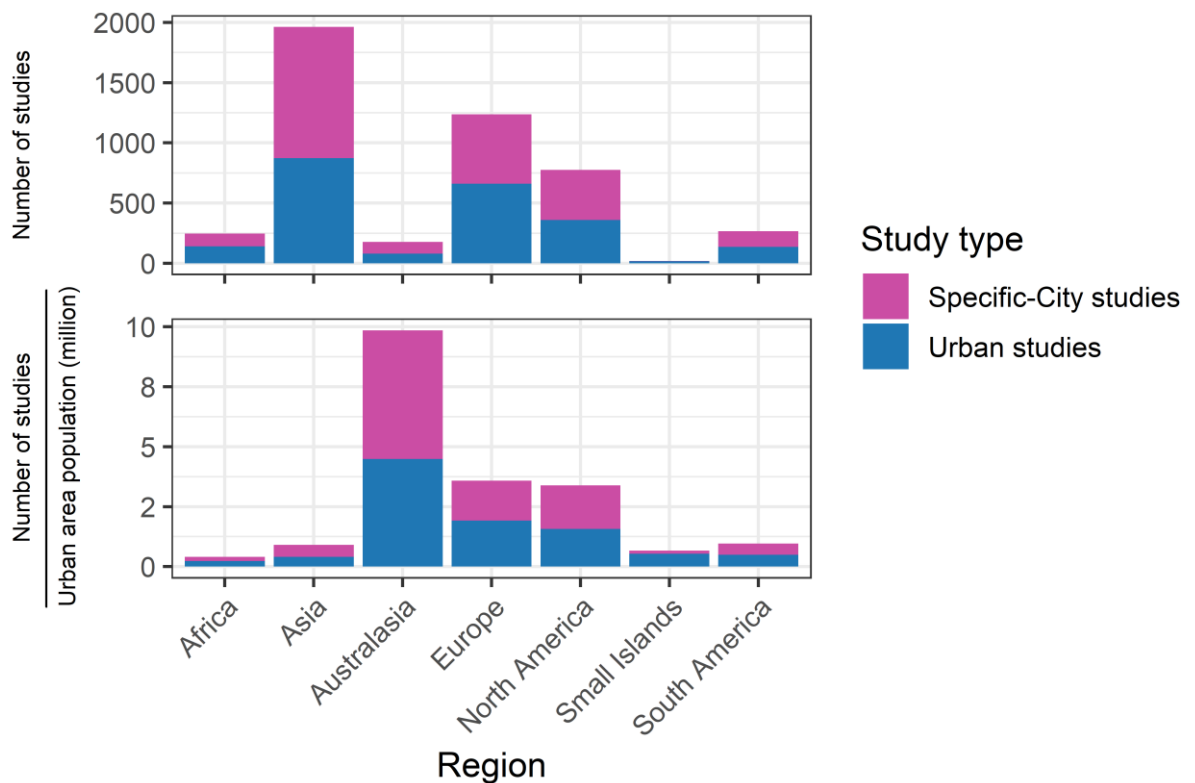


Figure S 5 Regional distribution of studies.

(a) Absolute number of studies by region, distinguishing specific-city and non-city-specific evidence. (b) Number of studies per million urban population (based on urban area population from GHS-UCDB in 2025) by region, highlighting population-adjusted

evidence intensity.

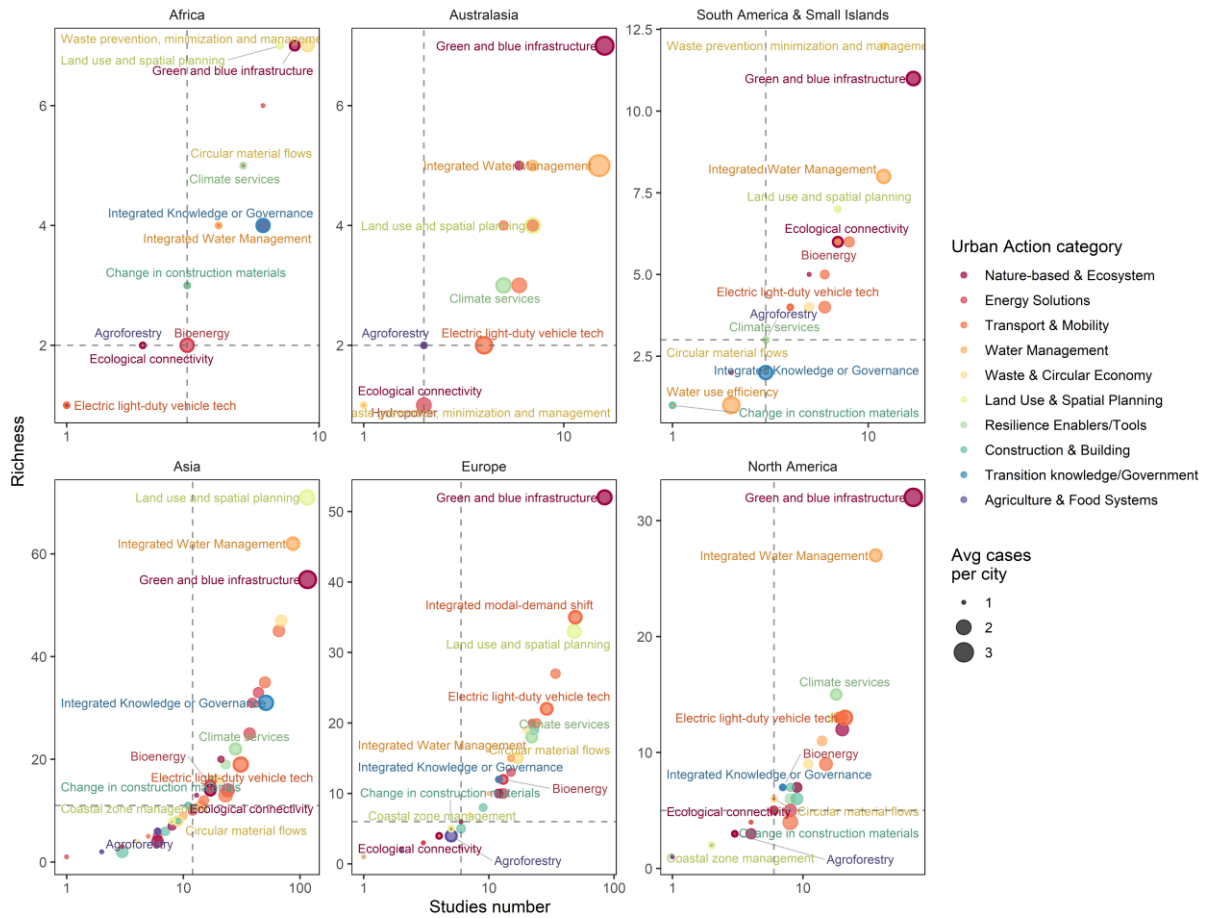


Figure S 6 Richness of urban actions with documented climate co-benefits by regions

The x-axis represents the total number of climate co-benefit cases within each city type, and the y-axis shows richness (number of individual cities covered). Each bubble represents a sub-action, with size indicating mean cases per city and color indicating urban action category. Dashed lines indicate the mean values of total cases and richness for each city type.

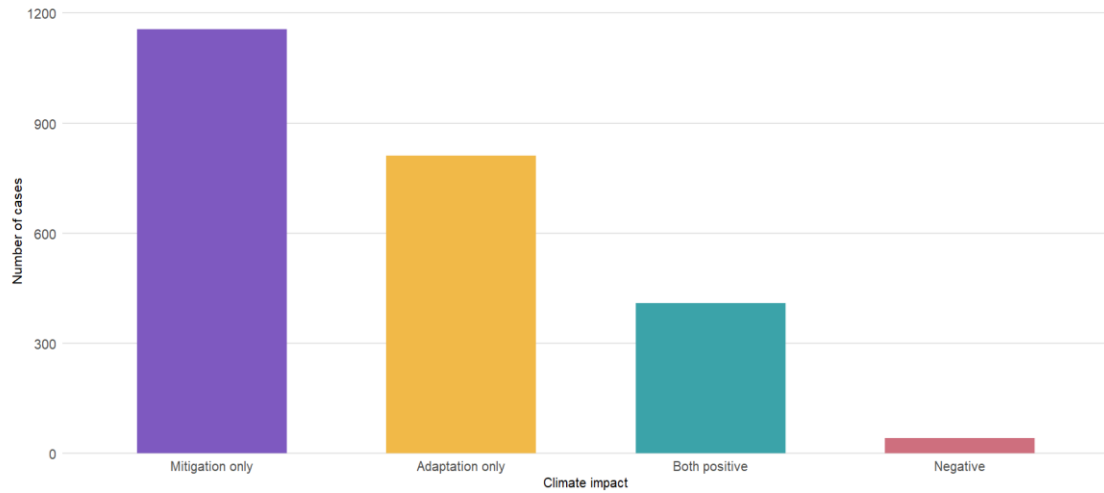


Figure S 7 The number of studies on climate impacts

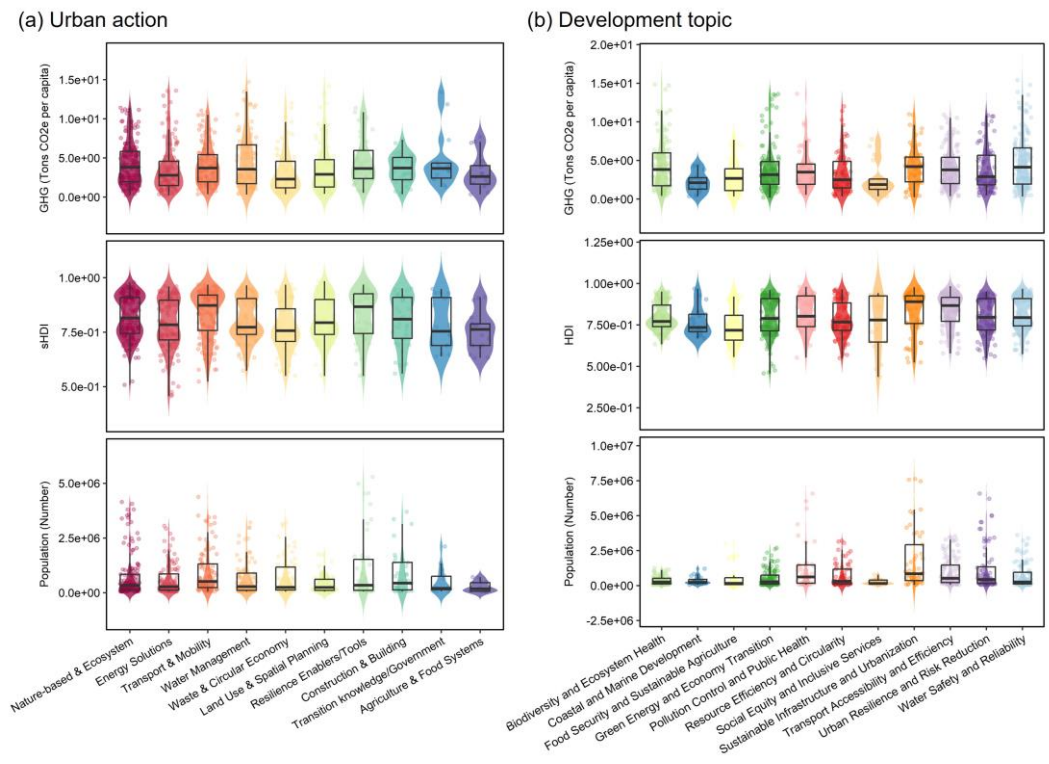
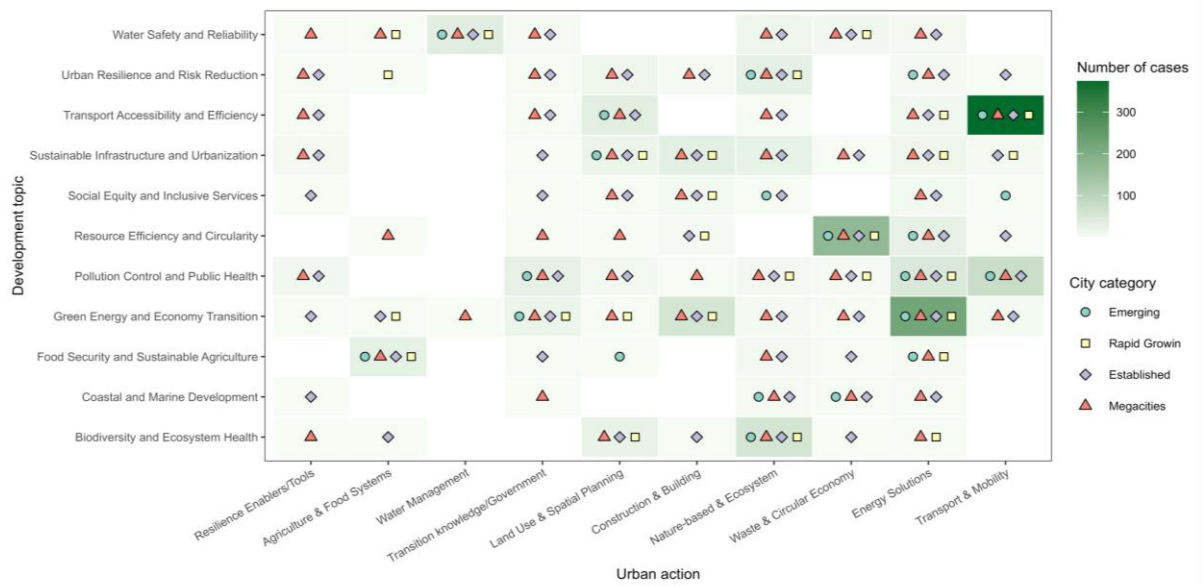


Figure S 8 Characteristics of cities across urban action and development-topic categories.

Boxplots show the distributions of GHG emissions per capita (CO₂e), Subnational Human Development Index (SHDI), and total population across (a) urban action categories and (b) local development topics, based on specific city studies collected. Categories are color-coded using a distinct palette to compare.

(a) Evidence of climate mitigation co-benefit



(b) Evidence of climate adaptation co-benefit

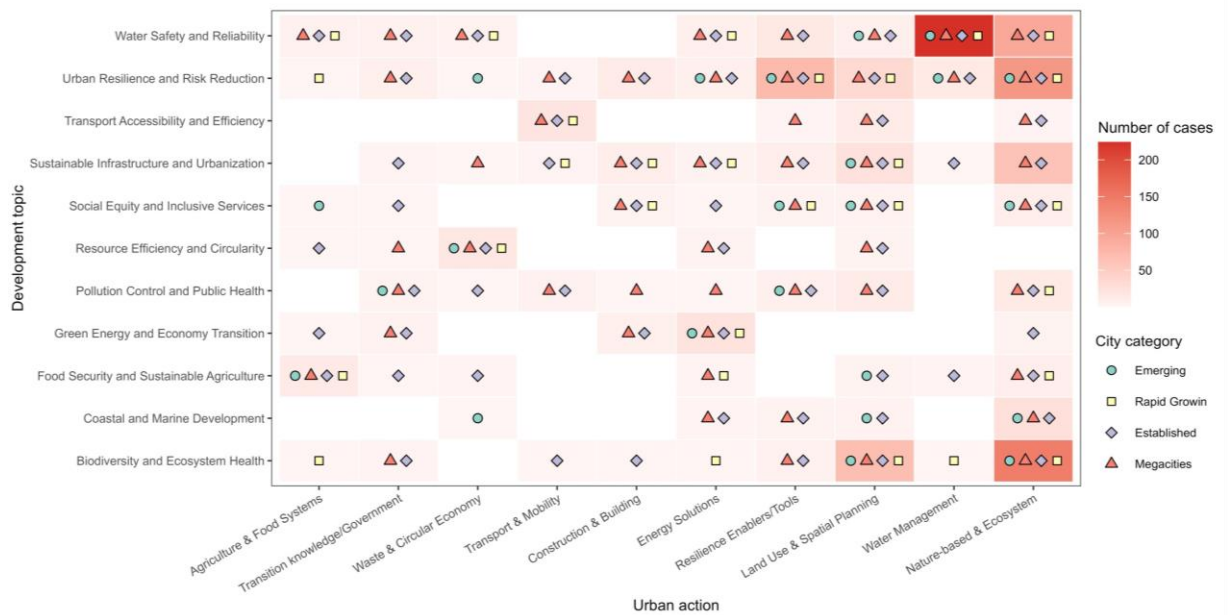


Figure S 9 Co-occurrence patterns of urban actions and local development topics.

Tile color indicates the total number of studies, with darker colors representing more evidence, with (a) climate mitigation-only, (b) climate adaptation-only evidence, respectively. Shapes denote the city types covered by the co-occurrence evidence.